WILDFIRE MODELING, IR OBSERVATIONS AND ANALYSIS

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ABSTRACT

In the NCAR wildfire modeling and observational program, modeling has been ongoing for about five years using a coupled atmosphere-fire model. This model is undergoing considerable development and results from a recent simulation showing a fire propagating over a small hill will be shown. However, the talk will concentrate mostly on observations from the last two years, as it is imperative to understand the nature of the beast that one is trying to model.

Observations and analyses from three different field experiments will be presented showing the small time and spatial scales in the convective processes that play a role in determining fire spread. The experiments are the NWT Crownfire modeling experiment in July of 1997, Northern Territory grass fire experiment near Darwin in June of 1998 and the WildFire Experiment at NCAR in August/Sept of 1998. IR video imagery and image flow analyses will be presented from these experiments.

We applied a gradient-based image flow analysis scheme to a sequence of high frequency (1/30 sec) radiant temperature images obtained by an Inframetrics ThermaCAM. We found that the motions during that crown fire had energy-containing scales on the order of meters with time scales of fractions of a second. Estimates of maximum vertical heat fluxes ranged between 1-3 MW/m**2 over the 4.5 minute burn, with early time periods showing surprisingly large fluxes of 3 MW m**2. Statistically determined velocity extrema, using 5 standard deviations from the mean, suggest that updrafts between 10 and 30 m/s, downdrafts between -10 and -20 m/s, and horizontal motions between 5 and 15 m/s frequently occurred throughout the fire.

A similar but more cursory analysis was applied to the observations of a prescribed spear-grass burn near Darwin, Australia. These observations were better resolved temporally because the camera was about 3 times the distance from the fire as in the NWT experiment. The raw IR imagery and subsequent fire wind analyses nicely show the convective character of the fire. Unlike the NWT experiment this case used an unstable tower, i.e. a 19 m high swaying cherry picker. As a result of ‘tower’ motion the apparent motion of the camera (or image registration) had to be considered before the fire winds could be recovered.

The final case was from a Herculies C-130 aircraft during the WiFE. Our first fire of opportunity was in the Glacier National Park (Challenge fire complex) where we observed some extremely interesting dynamic features. Fire wind rendering in these cases has all the apparent motion one could ask for to make the task of rendering the fire winds truly challenging.

In terms of learning (or in some cases validating) how convection affects fire spread we could identify two main vortex phenomena in our data. The first and most common was what we call enhanced vortex tilting resulting from horizontal vortices being tilted into the vertical rapidly so as to shear off the vortex leaving rotating towers of hot convection. This was common in the crown fire data and appear most prominent in the grass fire data. The second vortex phenomenon was the so-called hairpin vortex or turbulent burst. In this case the horizontal vortex is tilted without being sheared off resulting in a forward bursting vortex commonly observed in intense crown fires. The WiFE data shows one such hairpin bursting forward almost 70 m in a couple of seconds.